The Welfare Effects of Pfiesteria-Related Fish Kills: A Contingent Behavior Analysis of Seafood Consumers

George R. Parsons, Ash Morgan, John C. Whitehead, and Timothy C. Haab

We use contingent behavior analysis to study the effects of pfiesteria-related fish kills on the demand for seafood in the Mid-Atlantic region. We estimate a set of demand difference models based on individual responses to questions about seafood consumption in the presence of fish kills and with different amounts of information provided about health risks. We use a random-effects Tobit model to control for correlation across each observation and to account for censoring. We find that (i) pfiesteria-related fish kills have a significant negative effect on the demand for seafood even though the fish kills pose no known threat to consumers through seafood consumption, (ii) seafood consumers are not responsive to expert risk information designed to reassure them that seafood is safe in the presence of a fish kill, and (iii) a mandatory seafood inspection program largely eliminates the welfare loss incurred due to misinformation.

Key Words: pfiesteria, seafood demand, non-market valuation

Pfiesteria piscicida is a single-celled microorganism, a toxic dinoflagellate, found in the sediments of many estuaries in the Mid-Atlantic region of the United States. It has been identified as the cause of many fish kills in this region. Thousands, even millions, of fish can die in a single kill. During periods of warm weather and high nutrient concentrations, pfiesteria becomes a toxic predator to certain species of fish. While the scientific evidence suggests that these outbreaks are lethal to the fish, it also suggests that they pose no health risk to humans in the seafood market.[1] Nevertheless, media coverage of pfiesteria-related fish kills has led to rather large reductions in seafood consumption during periods of an outbreak. The associated loss in economic welfare is potentially quite large and is seemingly due to misinformation.

In this paper we measure the welfare effects of a hypothetical pfiesteria outbreak using contingent behavior analysis in a seafood demand model. We also consider the effects of different forms of information provision on attenuating the losses due to misinformation. Identifying the forms of information provision that have the largest positive impact on consumer behavior will provide important policy-based information for related government agencies and industry representatives seeking to reassure consumers of product safety and health concerns. Our research follows a framework developed by Shulstad and Stoevener (1978), who measured the welfare losses incurred by Oregon's pheasant hunters in reaction to news of mercury contamination in pheasants. Since then, researchers have considered the impact of news-induced health scares on the demand for a variety of goods. See, for example, Swartz and Strand (1981), Smith, van Ravenswaay, and Thompson (1988), Brown and Schrader (1990), Wessells

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George R. Parsons is Professor in the College of Marine Studies and Department of Economics at the University of Delaware in Newark, Delaware. Ash Morgan is Visiting Assistant Professor in the Department of Marketing and Economics at the University of West Florida in Pensacola, Florida. John C. Whitehead is Associate Professor in the Department of Economics at Appalachian State University in Boone, North Carolina. Timothy C. Haab is Associate Professor in the Department of Agricultural, Environmental, and Development Economics at Ohio State University in Columbus, Ohio. This work was (partially) supported by Grant No. NA86RG0036 from the National Sea Grant College Program, National Oceanic and Atmospheric Administration, to the North Carolina Sea Grant College Program. The authors thank Bob Christian, Isaac Kwakye, Emily Boyd, and Paul Hindsley for their contributions.

[1] For more information on Pfiesteria and its human health risks, see Kleindinst and Anderson (2001). A good website with links to bibliographies, background information, and public response is www.nal.usda.gov/wqic/pfiest.html.

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and Anderson (1995), and Wessells, Miller, and Brooks (1995). Ours is the first to consider pfiesteria-related fish kills and the first to use contingent behavior techniques to elicit consumers' stated preferences in this context. We begin with a brief discussion of our survey and study design before turning to the model.

Survey and Study Design

Contingent behavior or stated preference techniques are often used to measure consumer preferences. Individuals are asked to respond to survey questions pertaining to a market or non-market good. The provision of the good is altered in some fashion and the individuals are asked how they might respond to that change. In our case, respondents are asked how their seafood consumption might change in the presence of a pfiesteria-related fish kill.

We conducted a phone-mail-phone survey of seafood consumers over the age of 18 in Delaware, Maryland, Washington, D.C., Virginia, and North Carolina in 2001. The sample frame was stratified based on a split between urban and rural areas and a split between North Carolina and the other four areas. Pfiesteria outbreaks are common in the Mid-Atlantic, and we had a particular interest in North Carolina in our project. The goal was to conduct the survey during the fish kill season: June through November. The first phone survey was conducted from August to October. The second phone survey was conducted from October to November. The mail portion of the survey was mailed out to individuals between the phone surveys and contained information about pfiesteria.

Two focus groups were conducted to develop the pfiesteria information packet for mailing. The first focus group was conducted in Washington, North Carolina, and included five members of a local environmental organization. The second focus group was conducted in Baltimore, Maryland, with ten members of a church group. During each session, the facilitators presented sections of the information mailout and asked participants for their thoughts on what information they thought the text and visual aids conveyed. Overall, participants found the information straightforward. Where appropriate, suggestions received during these sessions were incorporated into the final version of the mailed information.

The survey questions were developed with input from participants in an East Carolina University undergraduate environmental economics course and during 15 one-on-one (telephone and in-person) interviews. Participants in the one-on-one interviews were chosen based on convenience. These sessions focused on question wording, organization, and skip patterns. Suggestions received during these sessions were incorporated into the final version of the questionnaires.

A pretest of 160 seafood consumers in Delaware, Maryland, North Carolina, and Virginia was also conducted during June–July 2001. Frequency and statistical analyses of the pretest data revealed no major flaws in the questionnaire. Only minor changes were made to the questions.

The first phone survey used random digit dialing and screened people based on whether or not they ate seafood.[2] The survey was designed to collect information on seafood consumption patterns, costs, knowledge of pfiesteria, and socioeconomic characteristics of respondents. In addition, each respondent was asked how his or her number of seafood meals consumed (monthly) would change if the price of seafood were to rise and to fall. The actual questions appear in Table 1 as Questions 1 and 2.

Individuals were recruited in the initial phone survey to participate in a follow-up phone survey. Between phone calls, individuals were sent an information mailout[3] which included the following:

- a hypothetical press release describing a pfiesteria-related fish kill
- information describing pfiesteria and its health risks
- a two-sided color pamphlet describing a new seafood inspection program.

The press release described either a major or a minor kill. A major kill involved hundreds of thousands of fish over a large area of a river. A minor kill involved fewer fish over a smaller area. Each respondent received one or the other of these press releases split about equally across our sample. The fish kill was on the Neuse River in

[2] Seafood meals are defined as finfish or shellfish meals consumed at home or in a restaurant. Not included are canned seafood meals or seafood meals consumed at other people's homes. Frozen seafood meals were eligible.

[3] Please contact the authors for copies of all the materials sent to respondents.

Table 1. Five Contingent Behavior Questions

Question #	Wording
Question 1: *Price up*	Seafood prices change over time. For example, if a lot of fish are caught, prices go down. When fewer fish are caught, prices go up. Suppose the price of your portion of your average seafood meal goes *up* by $X but the price of all other foods stays the same. Compared to the [NUMBER] meals you ate last month, do you think you would eat more, less, or the same number of meals next month with the higher price? (X is randomly assigned $1, $3, $5, or $7) *Then*, About how many more/less seafood meals do you think you will eat next month?
Question 2: *Price down*	Now suppose the price of your average seafood meal goes *down* by $X, but the price of all other foods stays the same. Compared to the [NUMBER] meals you ate last month, do you think you would eat more, less, or the same number of meals next month with the lower price? (X is randomly assigned $1, $2, $3, or $4) *Then,* About how many more/less seafood meals do you think you would eat next month with the lower price?
Question 3: *Fish kill*	Thinking about seafood meals again, suppose that the average price of your seafood meals stays the same. Compared to the [NUMBER] meals you ate last month, do you think you would eat more, less, or the same number next month after the fish kill? *Then,* About how many more/less seafood meals do you think you would eat next month after the fish kill?
Question 4: *Fish kill with inspection*	Now suppose the average price of your seafood meals stays the same. Compared to the [NUMBER] meals you ate last month, do you think you would eat more, less, or the same number next month after the fish kill and with the mandatory seafood inspection program? *Then,* About how many more/less seafood meals do you think you would eat next month?
Question 5: *Fish kill with inspection and price increase*	Suppose that with the mandatory seafood inspection program the price of your portion of your average seafood meal goes up by $X, but the price of all other food stays the same. Compared to the [NUMBER] meals you ate last month, do you think that you would eat more, less, or the same number next month after the fish kill? (X is randomly assigned $1, $3, $5, or $7) *Then,* About how many more/less seafood meals do you think you would eat next month?

North Carolina for North Carolina residents and on the Pocomoke River in Maryland for all others. The respondents also received a map pinpointing the location of the event.

The information sent to respondents describing pfiesteria and its health risks came in three different forms: (i) no information, (ii) a brochure, or (iii) a brochure and insert. Each respondent received one or the other of these packets split about equally across our sample. The brochure explains what pfiesteria is and notes that the risks of eating seafood are not changed as a result of the fish kills related to pfiesteria outbreaks.[4] The insert is more direct and emphasizes that there is no scientific evidence linking pfiesteria outbreaks to increased health risks in seafood consumption. Finally, each respondent was sent a short description of the National Oceanic and Atmospheric Administration (NOAA) voluntary seafood inspection program.

The second phone survey then focused on our next three contingent behavior questions: Questions 3, 4, and 5 in Table 1. Question 3 asked individuals how they would change their seafood consumption if the pfiesteria-related fish kill reported in the press release were to occur.[5] Question 4 asked the same question, but told respondents to assume that the government safety inspection program described in the pamphlet was

[4] The brochure is based on a brochure published by the U.S. Environmental Protection Agency's Office of Water titled "What you should know about Pfiesteria Piscicida." The brochure and insert information was simplified, shortened, and revised based on comments received from focus groups and from a review by an ecologist familiar with the pfiesteria scientific literature.

[5] Respondents were asked prior to questioning in the second survey if they had read the brochure and/or the insert. If they had not, then they were asked if they were prepared to do so, and told that they would be called back at a later date, allowing them time to read the information.

in operation. Question 5 asked the same question but told respondents that the safety program was in operation *and* that the price of seafood would increase as a result. These questions were designed to ascertain whether the seafood demand function shifted in the presence of a fish kill and if the inspection program attenuated that shift. The different treatments also allowed us to examine the extent to which demand shifts differ with different size fish kills and different information provided about health risks.

The first phone survey generated a sample of 1,790 respondents. The response rate was 61 percent—completed interviews divided by contacts, where contacts include refusals and completed interviews. Of these 1,790 respondents, 845 completed the second phone interview—a response rate of 47 percent. The mean annual income of our respondents was about \$50,000, the mean age was 47, and the mean education level was 2 years beyond high school. Thirty-six percent were male and 71 percent were white. All statistics are weighted to account for the sample stratification.

Model

We treat a pfiesteria-related fish kill as a factor affecting an individual's perception of the health risks associated with consuming fish. That perception, in turn, affects the individual's demand for seafood meals. In our analysis a seafood consumer has an indirect utility function over a fixed time period of the form $v = v(p, q, y, h(\mathbf{s}); \mathbf{c})$, where p is the price of a seafood meal, q is the price of a composite of all other goods, y is income for the relevant time period, h is the perceived quality of seafood, $\mathbf{s}$ is a vector of attributes that govern an individual's perception of quality, and $\mathbf{c}$ is a vector of individual characteristics accounting for heterogeneity of the population. Following conventional consumer theory, we expect $(\partial v/\partial p) < 0$, $(\partial v/\partial q) < 0$, $(\partial v/\partial y) > 0$, and $(\partial v/\partial h)\cdot(\partial h/\partial s_i) \geq$ or ≤ 0. The term s_i is one of i elements in the vector $\mathbf{s}$. The elements can affect perceived health risks positively or negatively, and in our application will pertain to the hypothetical pfiesteria-related fish kill and information on the health risks associated with a kill presented in our contingent behavior question.

Roy's Identity implies an uncompensated demand function for seafood meals of the form $-(\partial v/\partial p)/(\partial v/\partial y) = x(p, q, y, h(\mathbf{s}); \mathbf{c})$. In our application we use linear forms for $h(\mathbf{s})$ and $x(p, q, y, h(\mathbf{s}); \mathbf{c})$ to estimate seafood demand and the impact of fish kills on demand.

First, consider the contingent behavior questions for a change in the price of seafood. Individuals are asked how much their quantity demanded would change with a hypothetical change in price. Let Δx be the reported change in the quantity demanded and Δp be the size of the hypothetical price change.

In our demand model,

$$(1) \qquad x_0 = \beta_p p + \beta_q q + \beta_y y + \beta_h \boldsymbol{\alpha}'\mathbf{s} + \boldsymbol{\beta}'_{\mathbf{c}}\mathbf{c}$$

is the demand at the current price p, and $h(\mathbf{s}) = \boldsymbol{\alpha}'\mathbf{s}$. Similarly,

$$(2) \qquad x_1 = \beta_p (p + \Delta p) + \beta_q q + \beta_y y + \beta_h \boldsymbol{\alpha}'\mathbf{s} + \boldsymbol{\beta}'_{\mathbf{c}}\mathbf{c}$$

is the demand at the new price $p + \Delta p$. Subtracting equation (1) from equation (2) gives a demand difference

$$(3) \qquad \Delta x = \beta_p \Delta p,$$

where $\Delta x = x_1 - x_0$ is the reported change in the quantity consumed in response to the hypothetical price increase. The term $\beta_q(q - q) + \beta_y(y - y) + \beta_h \boldsymbol{\alpha}'(\mathbf{s} - \mathbf{s}) + \boldsymbol{\alpha}'_{\mathbf{c}}(\mathbf{c} - \mathbf{c})$ drops out of the demand difference by design. In the contingent behavior question there is no variation in income, other prices, risk factors, or individual characteristics between the current state and the hypothetical state.

In our application we estimate β_p using equation (3). Variation in price comes from the survey design—individuals receive different Δp's in the contingent behavior questions. For a price increase, Δp takes on a value of \$1, \$3, \$5, or \$7. For a price decrease, it takes on a value of -\$1, -\$2, -\$3, or -\$4 (see Questions 1 and 2 in Table 1).

We estimated separate equations for price-up and price-down. These are

$$(4) \qquad \begin{aligned} \Delta x_{Q1} &= \beta_{pu} \Delta p_{up} + \varepsilon_{Q1} \\ \Delta x_{Q2} &= \beta_{pd} \Delta p_{down} + \varepsilon_{Q2}. \end{aligned}$$

The method is the same for estimating shifts in demand due to the fish kill analyzed in the last three contingent behavior questions. In this case,

$$(5) \qquad x_1 = \beta_p p + \beta_q q + \beta_y y + \beta_h \boldsymbol{\alpha}'(\mathbf{s} + \Delta\mathbf{s}) + \boldsymbol{\beta}'_{\mathbf{c}}\mathbf{c}$$

is the demand with the hypothetical fish kill and $\Delta\mathbf{s}$ is a vector of the change in the factors that affect perceptions of risk. Subtracting equation (1) from equation (5) gives

$$(6) \qquad \Delta x = \beta_h \boldsymbol{\alpha}' \Delta\mathbf{s} \ .$$

$\Delta x = x_1 - x_0$ is the reported change in the quantity consumed in response to the hypothetical fish kill, and $\beta_p(p-p)+\beta_q(q-q)+\beta_y(y-y)+\boldsymbol{\beta}'_{\mathbf{c}}(\mathbf{c}-\mathbf{c})$ drops out of the demand difference since there is no change in p, q, y, and $\mathbf{c}$ between the current and hypothetical states in the contingent behavior question. Some elements in $\mathbf{s}$, however, do change by design, which gives rise to the specification in equation (6).

Now, consider Question 3 in Table 1. Individuals face either a major or a minor fish kill and are given one of three levels of information: (i) no information, (ii) a brochure, or (iii) a brochure and an insert. This gives the following form of our demand difference

$$(7) \qquad \begin{aligned} \Delta x_{Q3} = \ & \beta_h \alpha_1 \times \textit{major-kill} \ + \\ & \beta_h \alpha_2 \times \textit{minor-kill} + \\ & \beta_h \alpha_3 \times \textit{brochure} + \\ & \beta_h \alpha_4 \times \textit{brochure \& insert} + \varepsilon_{Q3}, \end{aligned}$$

where the right-hand side variables are our $\Delta\mathbf{s}$'s. We have *major-kill* (= 1 if kill is major), *minor-kill* (= 1 if the kill is minor), *brochure* (= 1 if respondent received brochure), and *brochure & insert* (= 1 if respondent received brochure and an insert).

The coefficients on *major-kill* and *minor-kill* are expected to be negative. The hypothesis is that individuals have misperceptions about the dangers of seafood consumption—believing it is dangerous to eat after a pfiesteria-related fish kill when in fact the danger is slight. The coefficients on *brochure* and *brochure & insert* are expected to be positive—information on risk shifts demand "back" to the right. The hypothesis is that the safety information counters the misperception of seafood health risks and reduces the extent of the leftward shift. The latter is a recovery of lost welfare due to poor information.

In Question 4, everyone is asked how his or her response to Question 3 would differ if a seafood inspection program had been in place. Question 5 is the same as 4 except that individuals are told that the inspection program will increase the price. The price increase was \$1, \$3, \$5, or \$7.

The equations for Questions 4 and 5 then are

$$(8) \qquad \begin{aligned} \Delta x_{Q4} = \ & \beta_h \alpha_1 \times \textit{major-kill} + \\ & \beta_h \alpha_2 \times \textit{minor-kill} + \\ & \beta_h \alpha_3 \times \textit{brochure} + \\ & \beta_h \alpha_4 \times \textit{brochure \& insert} + \\ & \beta_h \alpha_5 \times \textit{inspection} + \ \varepsilon_{Q4} \end{aligned}$$

$$(9) \qquad \begin{aligned} \Delta x_{Q5} = \ & \beta_h \alpha_1 \times \textit{major-kill} + \\ & \beta_h \alpha_2 \times \textit{minor-kill} + \\ & \beta_h \alpha_3 \times \textit{brochure} + \\ & \beta_h \alpha_4 \times \textit{brochure \& insert} \ + \\ & \beta_h \alpha_5 \times \textit{inspection} + \\ & \beta_h \alpha_6 \times \textit{price for inspection} \ + \varepsilon_{Q5}, \end{aligned}$$

where *inspection* equals 1 if the inspection program is in place, and *price for inspection* equals the price increase per seafood meal due to program.

Introduction of a seafood inspection program, *inspection*, would presumably work to shift demand "back" to the right—we expect a positive coefficient. The *price for inspection* should dampen the extent of the rightward shift since consumers realize they have to pay for the program—we expect a negative coefficient.

We estimate equations (4), (7), (8), and (9) simultaneously as a linear model with eight parameters.[6] Simultaneous estimation allows us to constrain parameters across equations to be constant and to estimate the model with random effects. Random effects allow the error terms in the model to be correlated across equations for each observation. It stands to reason that the same unobserved elements that influence an individual's shift in demand due to a fish kill without an inspection program will also influence that indi-

[6] The eight parameters are β_{pu}, β_{pd}, and $\beta_h \alpha_1$ through $\beta_h \alpha_6$. Since the individual parameters β_h and α_i are not identified in our model, we estimate $\beta_h \alpha_i$ as a single parameter for each i. This has no bearing on our final welfare calculations.

vidual's shift with an inspection program in place. Since all observations in the sample do not make it to the second survey and since there is some attrition due to simple cleaning of the data, an unbalanced version of a random effects model is estimated.

The model is also estimated as a Tobit regression with censoring at $-x$, the negative of the quantity consumed. This is because individuals cannot reduce their consumption of fish by more than the quantity consumed. Since individuals consume different quantities, the censoring point varies across observations.[7]

Finally, we use the estimated model to report the change in consumer surplus due to hypothetical major and minor fish kills. This surplus loss is sometimes called "avoidance cost." It is the loss associated with avoiding fish consumption when in reality fish is safe to eat. It is the difference in an individual's consumer surplus with and without a fish kill. In the linear demand model, an individual's loss is $\{(x+\Delta x)^2 - x^2\}/-2\beta_p$, where x is reported monthly consumption, Δx is the reported change due to a fish kill, and β_p is from the estimated model. We report these losses under different assumptions about information provision.[8]

Results

The regression results appear in Table 2. These are random effects Tobit regressions with censoring at the negative of the number of meals consumed. Table 3 shows the change in surplus or avoidance cost due to minor and major fish kills per seafood meal. We report surplus losses assuming that (i) individuals have no information, (ii) individuals have a brochure, (iii) individuals have a brochure and an insert, (iv) an inspection program is in place, and (v) an inspection program is in place and there is a price rise.[9]

There are several noteworthy findings. First, the effects of a price increase and a price decrease differ—the slope of the demand function is larger for a decrease than for an increase. The coefficient on Δp_{down} is -.346, and the coefficient on Δp_{up} is -.218. At the mean, this is a price elasticity of demand of .78 for a price decrease and .49 for a price increase. In effect, there is a "kink" in the demand function at the point of current consumption. Quantity demanded seems to be more responsive to a price decrease than a price increase. This finding appears to be consistent with theories of loss aversion—that individuals value losses more highly than gains of equivalent magnitude. One may be inclined to argue that this is due to individuals' inability to reduce consumption beyond their current level, thereby capping the response to price increases. However, keep in mind that we have estimated a version of the model that accounts for truncation at current consumption.

Second, the coefficients on *major-kill* and *minor-kill* are negative and significant as expected. This general result is supported by other studies [see Anderson and Anderson (1991) or Ahluwalia, Burnkrant, and Unnava (2000)]. What is unexpected is that the effect of a major kill and a minor kill are about the same. There is no statistical difference in their coefficients. The implication is that the size and scope of a fish kill is not particularly important. Hundreds of thousands

[7] There are a number of ways the model could have been more complex econometrically. In principle, we have a difference of two count data variables for our dependent variable. This introduced a number of complications that make a simple count model (our first choice) for the demand differences infeasible: some of our differences are negative, the distribution of the difference of two count variables is not a simple count variable [see for example Consul (1989)], and we really have a difference of *two* censored variables at *two* points. The econometrics gets complicated and is not really sorted out in the literature as far as we can tell. Our purpose in this paper is to present a simple slice of the data using some basic econometric techniques. We think there are some interesting findings to share in this regard alone.

[8] We report welfare changes using the price-up coefficient, β_{pu}, in equation (4) since all the measures of surplus we consider are integrated over the portion of the demand curve corresponding to a price increase.

[9] Two caveats are worth noting here. First, since we question people about the number of seafood meals (and change in the number of seafood meals) consumed in a month, in a sense they have "recent" information about the kill for each meal in a month. Following an actual kill, an individual will have "recent" information for only a day or so, not a full month. If an individual's reaction to information changes as time passes, our estimates will be biased. For example, a press release may have a large impact in only the first few days, its impact thereafter diminishing. Whether or not people mimic that type of behavior in our survey is uncertain. To the extent that there is decay in the effect of a fish kill on consumption of seafood over a month, we may be overstating the impact. Second, since we use a composite measure of seafood, we miss substitution across types of seafood that may occur as a result of a pfiesteria outbreak. For example, if a person changes the type of fish he or she eats in response to the outbreak but does not alter his or her total seafood consumption, there is a welfare loss. In our model, we would observe no change in seafood consumption and no welfare loss. In this respect, our analysis will understate welfare losses.

Table 2. Regression Results[a]

Variable		Parameter Estimates for Equations 4, 7–9: Coefficient	t-statistic
Δp_{up}	Amount of price increase	-.218*	-13.7
Δp_{down}	Amount of price decrease	-.346*	-14.3
major-kill	Dummy variable for major fish kill	-1.19*	-8.0
minor-kill	Dummy variable for minor fish kill	-1.27*	-9.2
brochure	Dummy variable for brochure included	-.089	-0.7
brochure & insert	Dummy variable for information insert included	.076	0.6
inspection	Dummy variable for inspection program in place	1.06*	8.0
price for inspection	Amount of price increase due to seafood program	-.183*	-6.8
Sigma(v)		2.14	197.7
Sigma(u)		.191	1.5

[a] Random-effects Tobit model with censoring at the negative of the number of meals purchased per month and allowing for correlation across 5 contingent behavior questions.

Note: Asterisk means statistically significantly different from zero at the 99 percent level of confidence.

Table 3. Avoidance Cost Estimates Due to Fish Kill[a]

Information Scenario	Average Change in Consumer Surplus per Meal: Major Kill	Minor Kill
With no information	-\$4.17	-\$4.34
With brochure	-\$4.38	-\$4.54
With brochure & insert	-\$4.20	-\$4.37
With inspection program	-\$0.60	-\$0.92
With inspection program and \$1 price increase in meals	-\$1.37	-\$1.65

[a] Average change in consumer surplus per meal per person for a major and minor fish kill assuming different levels of information provision.

of dead fish signal an increase in health risk comparable to tens of thousands of dead fish.[10] The welfare loss associated with the fish kills, ignoring for the moment the cases with information provision and inspection programs, is on the order of \$4 *per meal*.

[10] One referee noted an alternative interpretation: perhaps our contingent behavior survey failed to pass a scope test [see Hanemann (1994), p. 34].

Third, information provision in the form of a brochure or a brochure along with an insert appears to have limited sway on consumers. The coefficients on *brochure* and *brochure & insert* are statistically insignificant. It follows that the welfare loss associated with the fish kills assuming individuals have a brochure or have a brochure and the insert is about the same as the cost with no information. This finding seems to suggest that simply providing information based on experts' judgments carries little weight in altering individuals' perceptions. It is also possible that the manner in which the information was packaged and presented was the cause for the limited impact—people ignored it or found that it lacked credibility. For example, the brochure is rather long and may simply be disregarded. Or, what was intended to make consumers feel safe may have inadvertently raised an issue they had not really considered before. For a discussion of the credibility of the sources of information, see Hovland and Weiss (1951), Sternthal, Phillips, and Dholakia (1978), Smith, Young, and Gibson (1999), Tse (1999), and Frewer, Scholdere, and Bredahl (2003).

These coefficients are consistent with the argument that positive information has less of an effect on consumer behavior than negative media coverage. The "negative" press releases shifted demand significantly; the "positive" brochures shifted it only slightly. Kroloff (1988) found that the impact of media exposure gives negative news quadruple weight compared with positive news. Sherrell et al. (1985) calculated that it takes five times more positive information to offset the effects of any negative information.

Fourth, the presence of an inspection program, unlike information provision, shifts the demand function significantly rightward—returning it close to its pre-fish kill position. The coefficient on *inspection* nearly perfectly offsets the initial shift due to the hypothetical fish kill. The coefficient is also statistically significant. This result is consistent with Wessells and Anderson (1995), who considered the role of a variety of measures of providing seafood safety assurances and found that consumers placed a high value on seafood inspection programs. So, the cost of the kill, with an inspection program in place, drops dramatically, as shown in Table 3. The curious thing here is that inspection programs would discover nothing related to pfiesteria that one could actually act upon to reduce risk, since pfiesteria poses no health threat to humans who consume infected seafood to begin with. In this regard a program may comfort consumers, but it would be a somewhat peculiar government response.

Fifth, the impact of a rise in seafood prices due to an inspection program is about the same as a general price rise—a sensible result. The coefficient on Δp_{up} is -.218 and on *price of inspection* is -.183. This has the potential of offsetting some of the recaptured losses due to the inspection program. In Table 3 we present the welfare loss for a fish kill assuming an inspection program is in place and raising the price of fish by $1.

Conclusions

As expected, individuals react to fish kills by reducing consumption of fish, even though the fish kill is unlikely to pose increased health risks. This result has been documented elsewhere in the literature and suggests that there may be a role for government in providing information to consumers about risks.

When individuals reduce seafood consumption, they are said to incur avoidance costs—welfare loss associated with unnecessarily avoiding a desirable meal. The benefit of a government information program then is the avoidance cost saved by informing consumers. The avoidance costs in question appear to be rather large. Using our model, the aggregate cost over the four-state region is on the order of $60 million per month, depending on the amount of risk information provided to individuals.

We found that consumers were not responsive to "expert" risk information sent in a mail packet in the form of a brochure. The brochure emphasized that eating fish after a kill was safe. For the most part, individuals behaved as they would have without the information. The savings in avoidance cost were small. Perhaps experts have little sway in how individuals form perceptions of risk. Or, perhaps our information packets and method of dissemination failed to communicate the risk meaningfully or individuals simply ignore the information.

On the other hand, we found that consumers were quite responsive to seafood inspection programs. Avoidance costs are nearly eliminated by the hypothetical inspection program used in our experiment. This suggests that consumers have confidence in such programs and that concrete action by government authorities can affect consumer decisions. These results hold even though inspections programs, in principle, could discover nothing related to pfiesteria that one could actually act upon to reduce risk since pfiesteria poses no health threat in seafood. We also found that the gain in surplus realized by such programs can be easily dissipated if individuals believe the programs will lead to a rise, even a small rise, in the price of fish.

There were a number of other interesting findings. Individuals did not seem to differentiate between major and minor size fish kills. We surmised that there is some threshold level that triggers a response by consumers and that our kills surpassed that threshold. We also found that the people responded asymmetrically to price increases and price decreases—people were more responsive to price decreases.

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